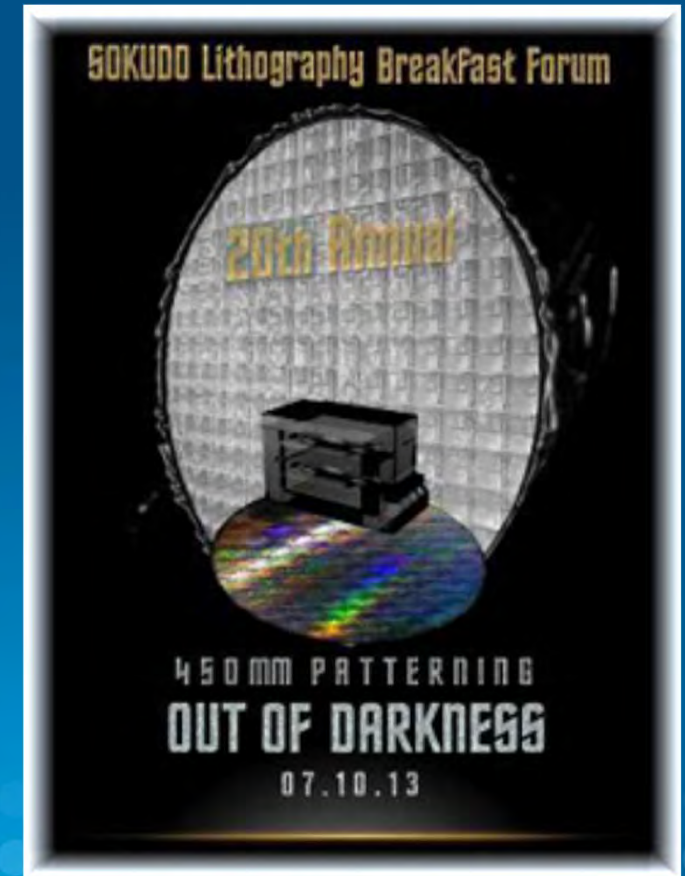


Advanced Sub-20nm 450mm Lithography

*Platform Maturity
and Wafer Availability*



Paul Hofemann
Corporate Marketing &
Business Development



Molecular Imprints™

Corporate Profile

▶ Global Nanoimprint Leader

- Headquartered in Austin, Texas
- Installations and commercial partnerships established in semiconductor memory and HDD
- DNP commercial imprint mask partnership
- Eleven years experience and over \$165 million invested

▶ Strategic Objectives

1. Capture substantial share of the existing \$6B semiconductor lithography equipment market
2. Utilize MII's low cost lithographic capability to enable new nanotechnology markets

INVESTORS



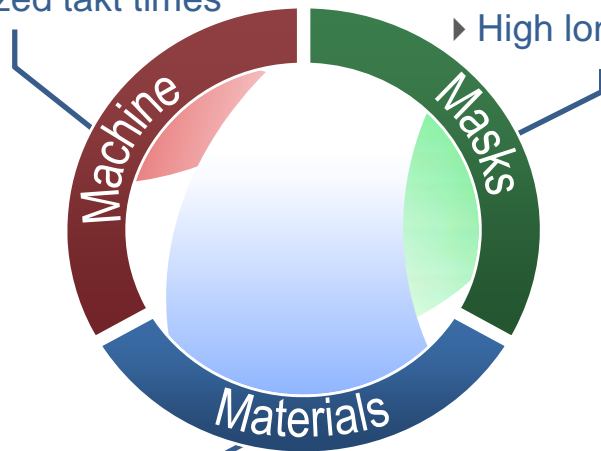
||| Silent Investors

Jet and Flash™ Imprint Lithography

With twelve years and \$165M invested, there are 160 patents issued in US and 250 people working on J-FIL full-time around the world

- ▶ 1.5 picoliter resist jetting
- ▶ Precision mechanics
- ▶ Optimized takt times

- ▶ Sub-20nm mask
- ▶ Low cost replication
- ▶ Low defect
- ▶ High longevity



- ▶ Low viscosity
- ▶ 193-like resist performance
- ▶ Low particulates
- ▶ High adhesion to substrate

J-FIL™ Advantages

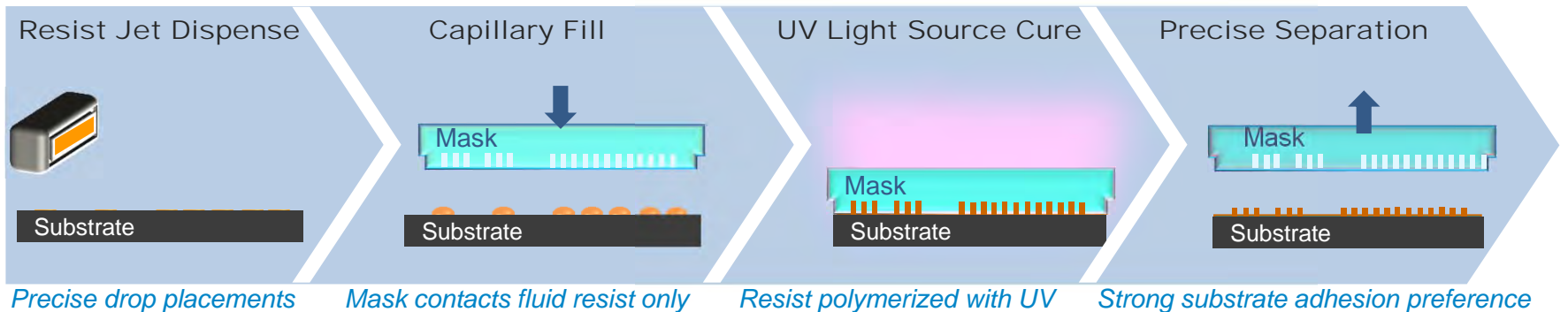
- ▶ **Sub-20nm Lithography with a Single Patterning Step**

- ▶ **Lowest Cost of Ownership**

- ▶ **Technology is Adaptable to Broad Applications**

- CMOS, Flat Panel Displays, Hard Disk Drives, Biotechnology, Clean Energy

Jet and Flash™ Imprint Lithography (J-FIL™)



Proprietary, patented lithography technology with higher performance and lower cost than traditional optical products

Very High Resolution Nanoscale Patterning

- No wavelength of light imaging restrictions
- Room temperature process allows accurate overlay and high throughput

Low Cost of Equipment and Operation

- Significantly cheaper than optical lithography tools
 - No lens
 - No laser light sources
 - No tracks
 - No material wastage

Large Print Area

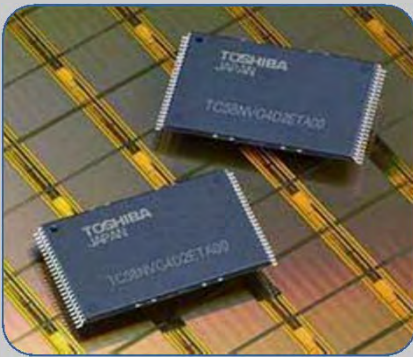
- Not limited by optical field sizes

Technology is Adaptable to a Variety of Applications

- Semiconductors
- Flat Panel Displays
- Hard Disk Drives
- HB-LEDs
- Biotechnology
- Clean Energy (Solar, Battery)

Key Market Opportunities

Semiconductor



Memory ICs

Flat Panel Displays



Wire Grid Polarizers

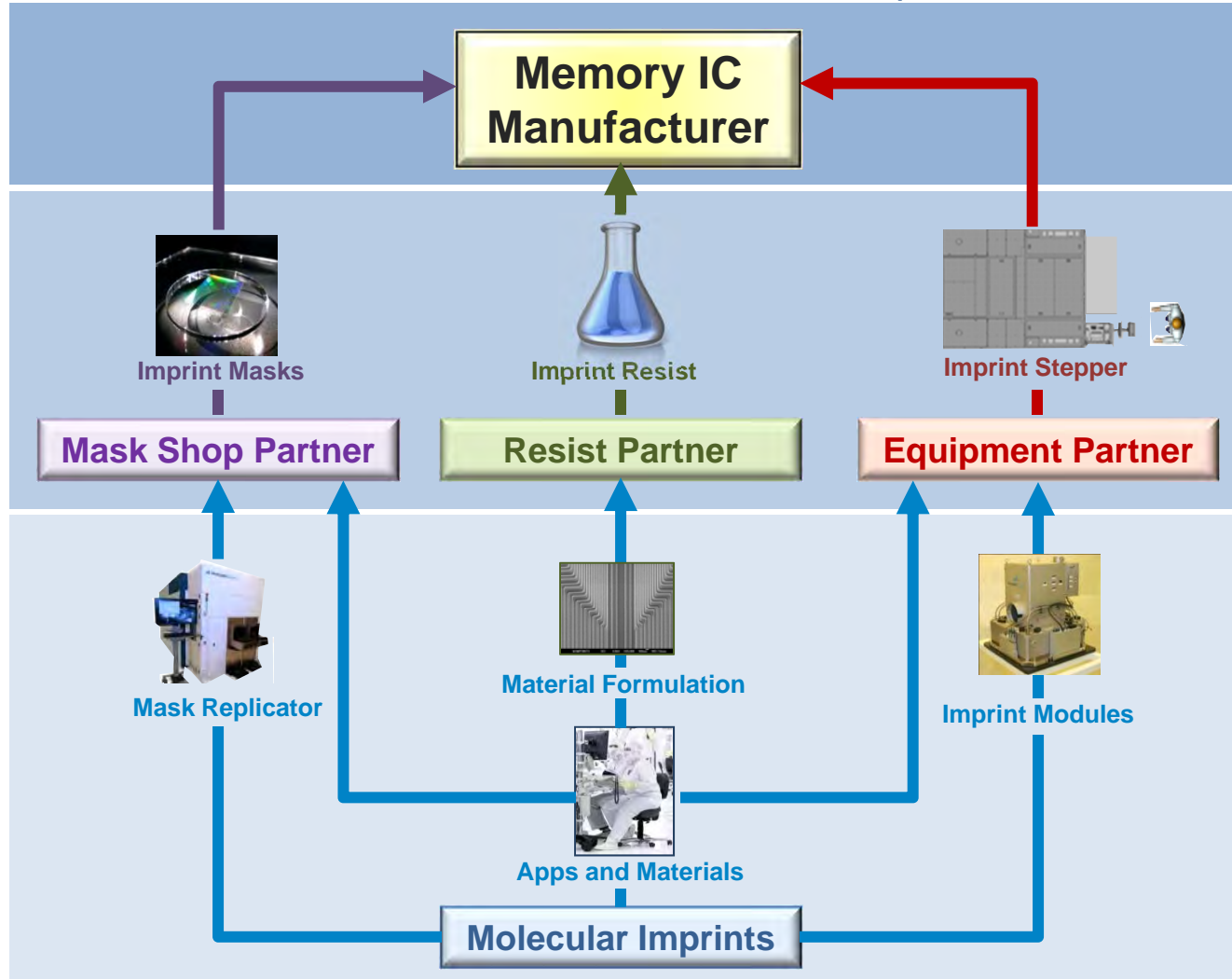
Hard Disk Drives



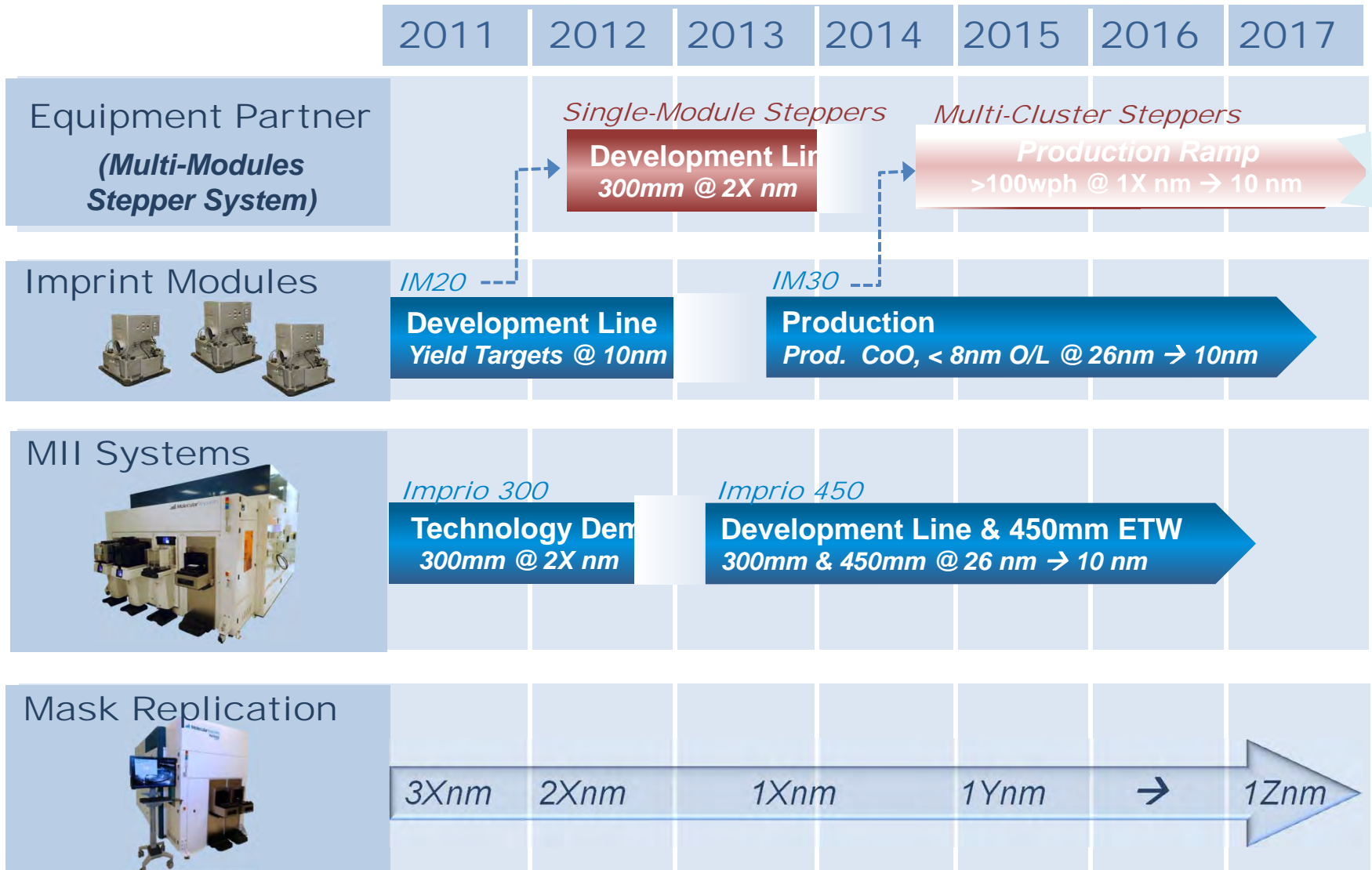
Bit Patterned Media

Semiconductor J-FIL™ Collaboration

Collaborative Relationships



Semiconductor Platform Roadmap

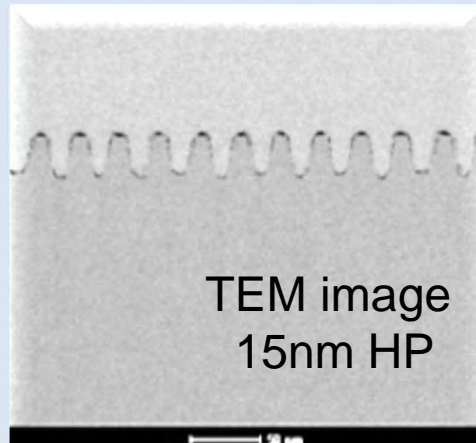
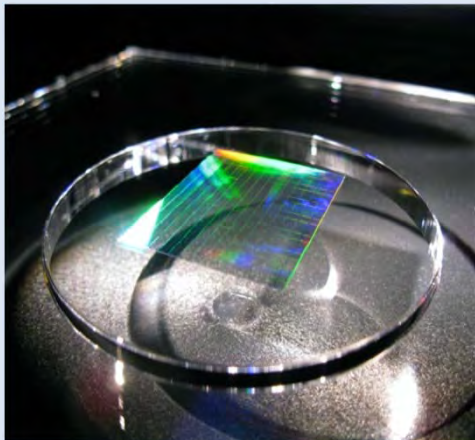


Commercial Mask Supply

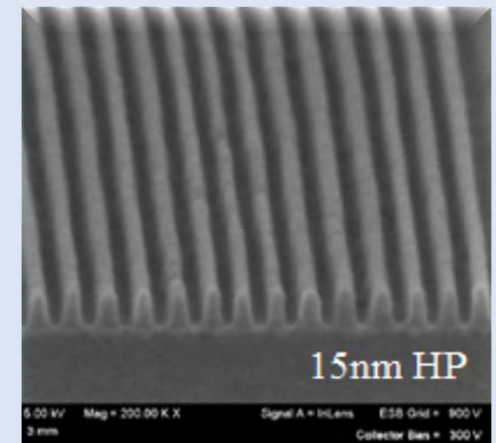


Master/Replica @ 2x nm	Target	2012	X: 2.47nm, 3 σ	Y: 2.23nm, 3 σ
Master defectivity (cm ⁻²)	0	0 with repair		
Replica added image placement (nm, 3 σ)	< 2	<2		
Replica defect density cm ⁻²	<1	3		
Replica CDU (nm, 3 σ)	2	1.5		
Defect repair of masters	Yes	In use		

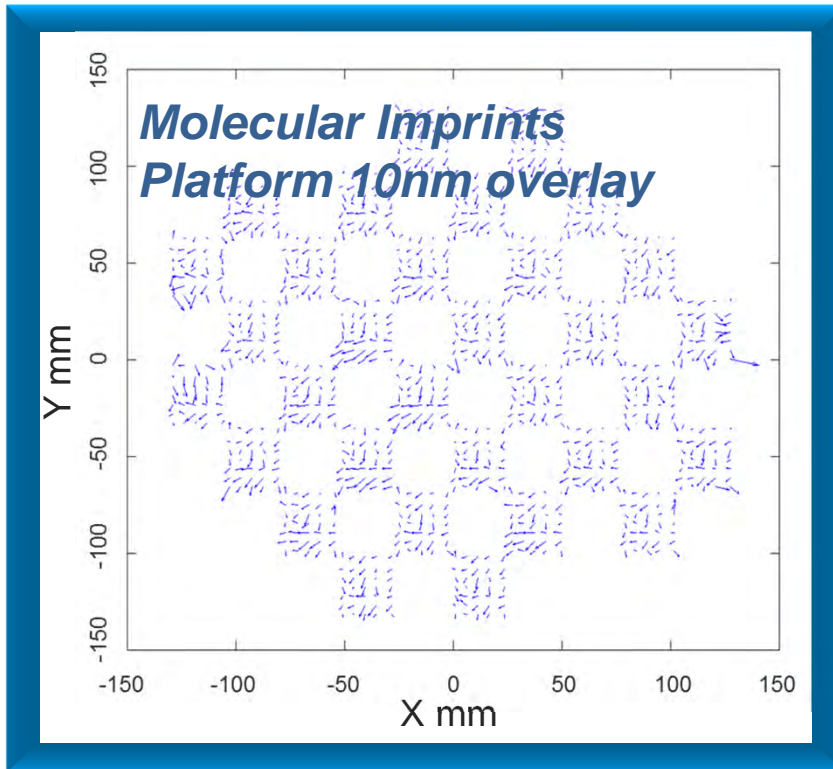
6025 Imprint Mask



Imprinted Resist Lines



Overlay Performance



Number of fields measured: 32
Number of points per field: 30

	X	Y
Raw Mean	-0.10	-0.63
Raw 3sigma	9.40	9.68
Mean + 3sigma	9.5	10.31

- ▶ Biggest error sources:
 - Replica Imprint mask image placement
 - Wafer chuck anomalies

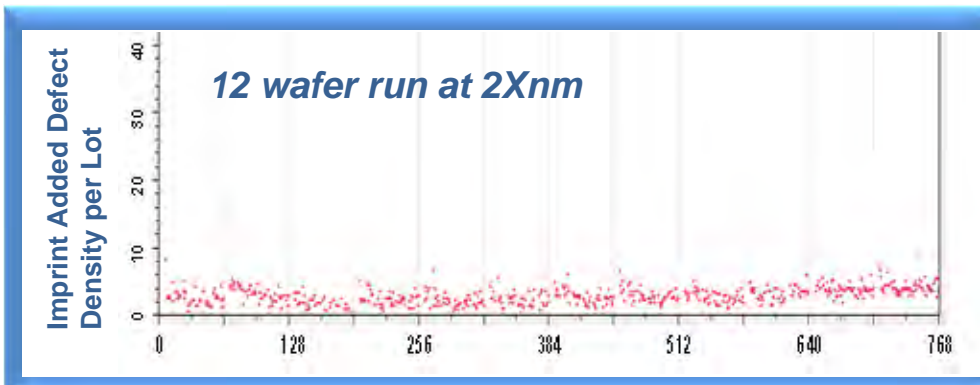
Further improvements to the mask and to the wafer chuck have resulted in **current mix and etch overlay of 8nm**

Defectivity Improvements



Several orders of magnitude improvement over last two years

- ▶ *Precise mask separation control*
- ▶ *Onboard resist filtration system*

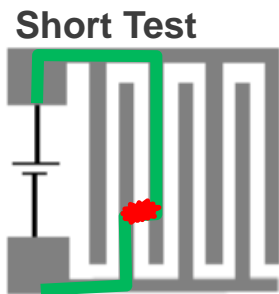
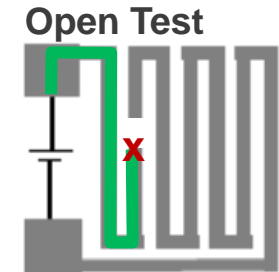


Low defect adders from imprint during multiple wafer runs

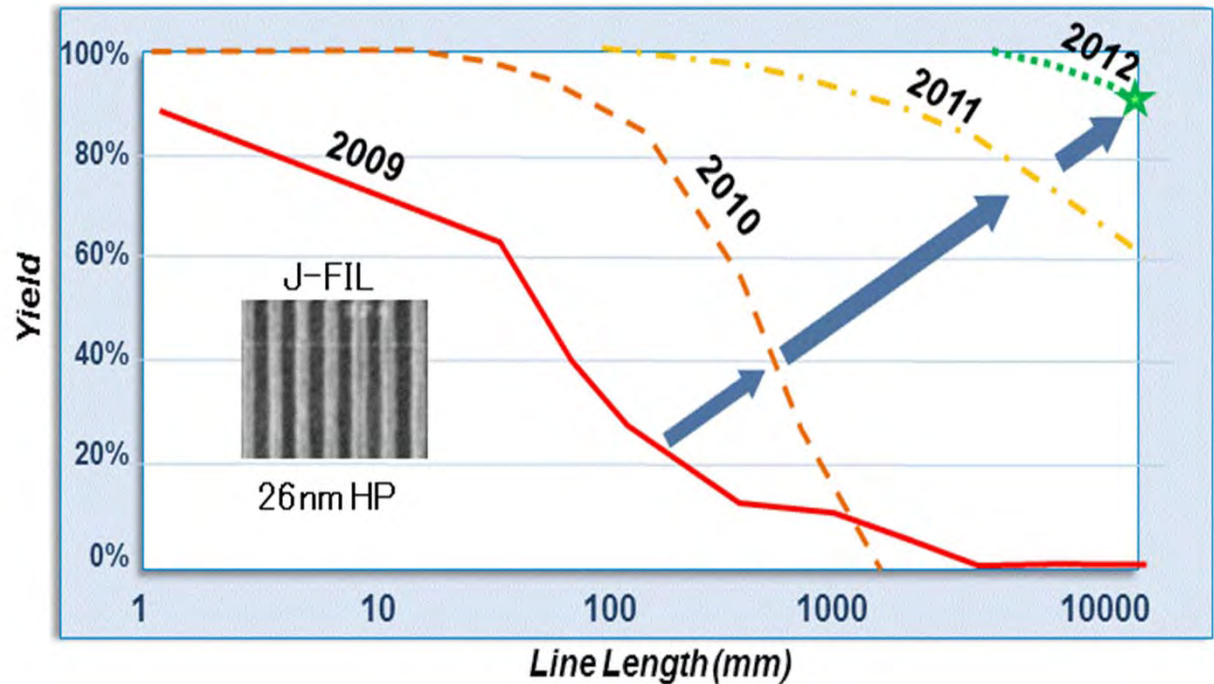
- ▶ *4.7 pcs/cm² per lot (25 wafers)*

Imprint Electrical Yield >90%

Test Patterns



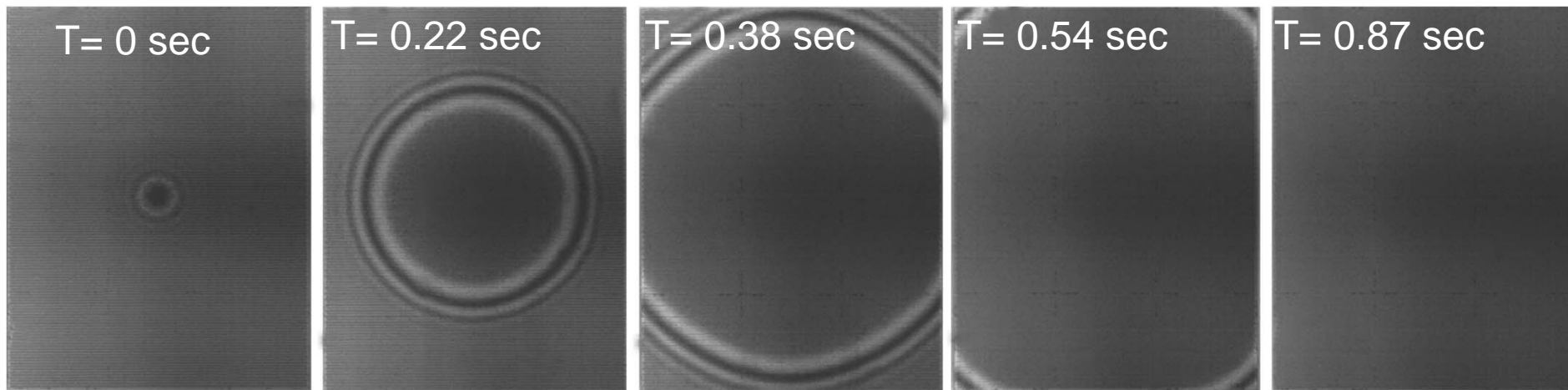
Electrical Defect Testing: Yield vs. Line Length



- ▶ Toshiba presented during 2012 SEMATECH Litho Forum and stated verbally that yields >90% have been achieved at 10 meter line on a few runs.
- ▶ Even more progress expected with next generation onboard resist filtration and mask replica defect improvements.

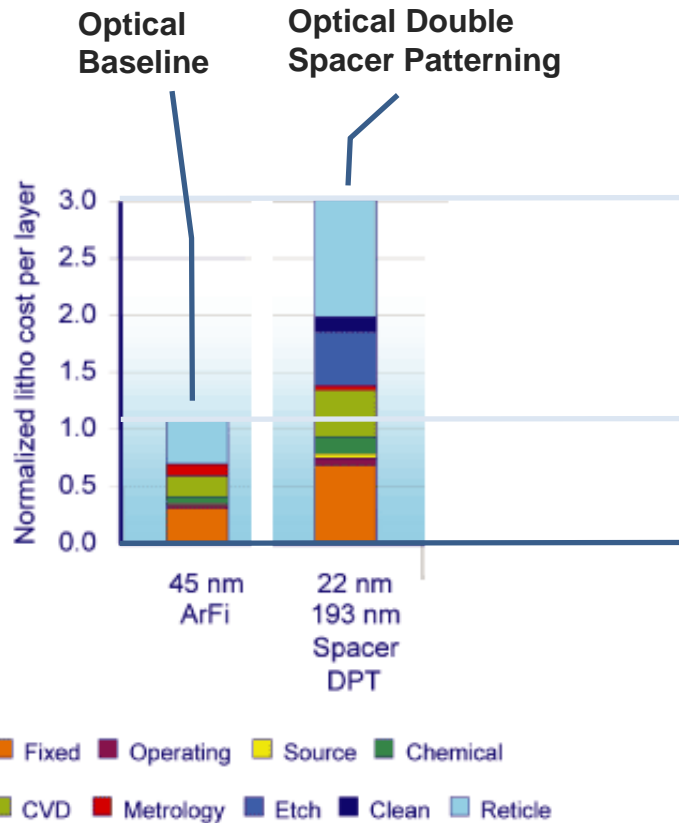
>100wph Imprint Stepper Development

- ▶ For High Volume Manufacturing, resist fill times of less than 1 second are required for stepper system throughput of > 100 wph (300 mm)
- ▶ Keys to Fast Fluid Fill
 - *Small drop volume: Pico liter sized drops*
 - *GDS based volume targeting*
 - *Fluid front control*
 - *Low viscosity imprint resists*
 - *Materials optimized for wetting and filling performance*



J-FIL Cost of Ownership Advantage

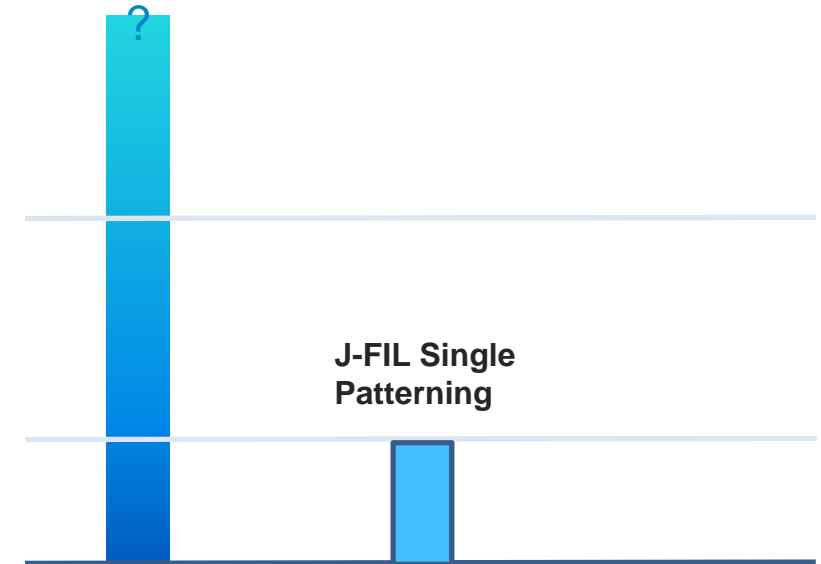
TODAY



( **ASML Estimate**)

Optical Quad
Spacer Patterning

FUTURE



Step	193i SAQP
1	Bottom mandrel ACL dep
2	Oxide dep
3	Top mandrel ACL dep
4	Nitride cap dep
5	BARC deposition
6	193i litho
7	BARC etch
8	Nitride cap etch
9	Top mandrel ACL etch
10	Wet strip of nitride cap
11	Nitride spacer 1 dep
12	Nitride etch back
13	top mandrel strip
14	oxide etch
15	Bottom mandrel etch
16	Wet clean of & strip
17	Nitride spacer 2 dep
18	Nitride etch back
19	Bottom mandrel strip
20	Cut layer litho & process
21	Pad layer litho & process

Imprint
Deposit ACL
Deposit Hardmask
Deposit Adhesion layer
Imprint lithography
Descum
Hardmask Etch
ACL etch

(**MII Estimate**)

NAND FLASH Manufacturing Ramp by 2015

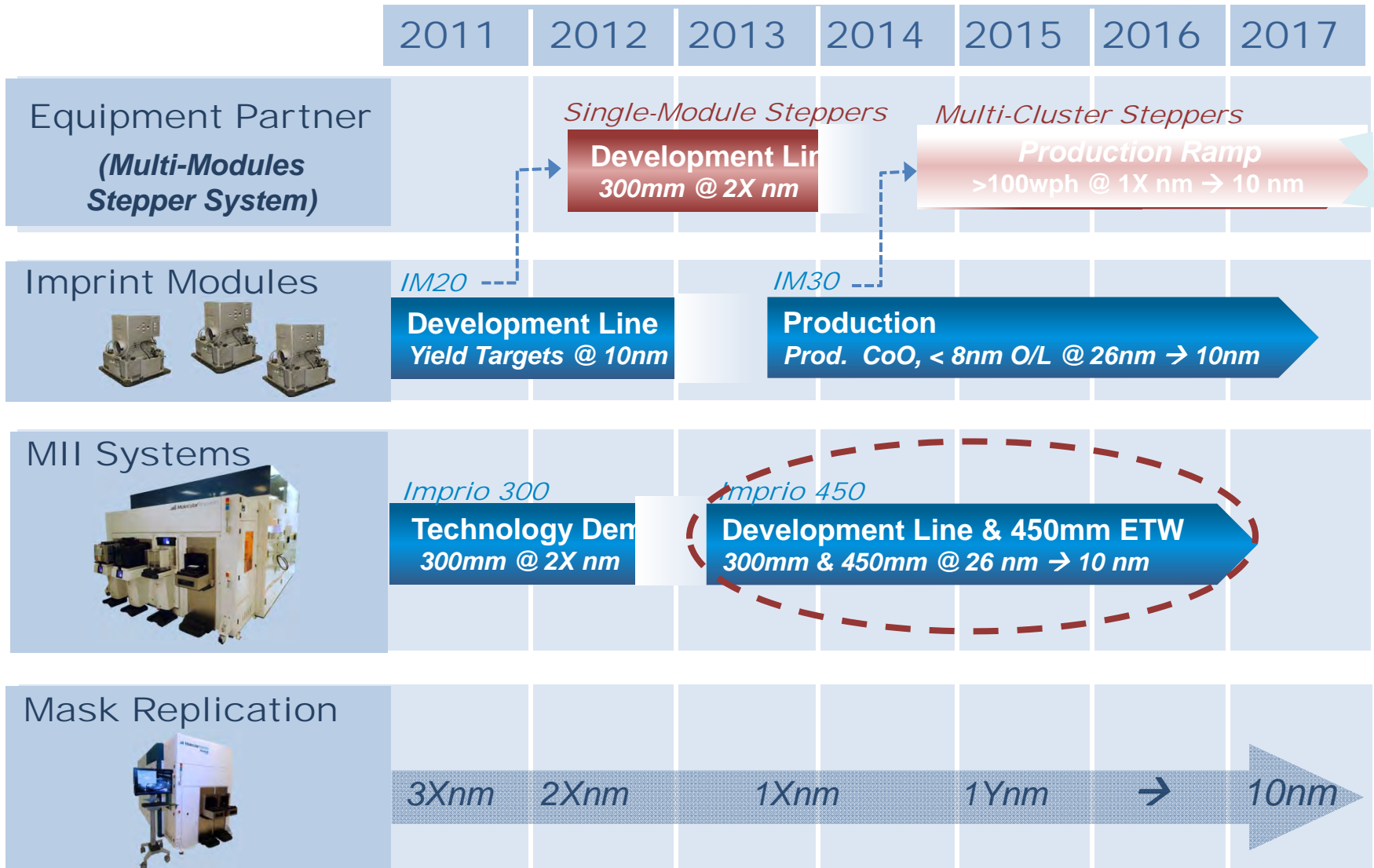


Large semiconductor manufacturer has plans to ramp J-FIL™ into advanced memory production in 2014!

- ▶ Multiple systems already installed for nanoimprint performance refinement and device process integration
- ▶ Industry infrastructure readiness;
 - Equipment partner experienced in building and shipping J-FIL™ steppers
 - High quality DNP commercial imprints masks available today



Semiconductor Platform Roadmap



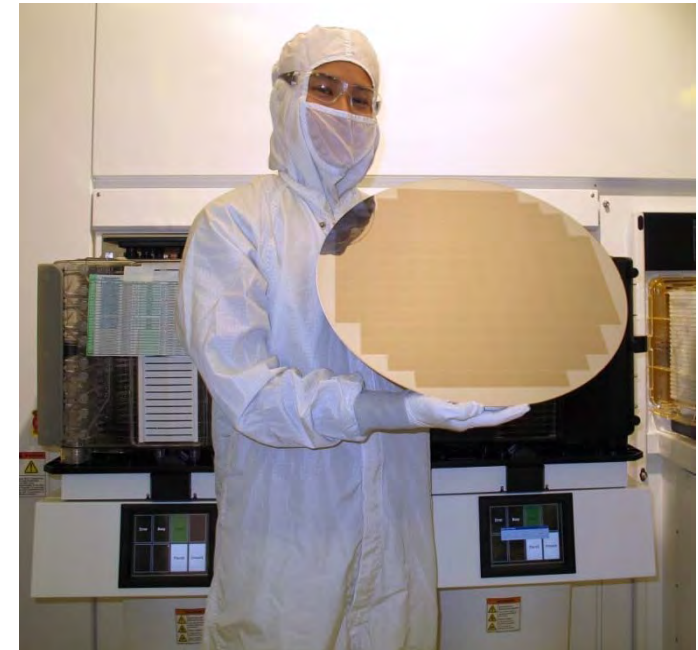
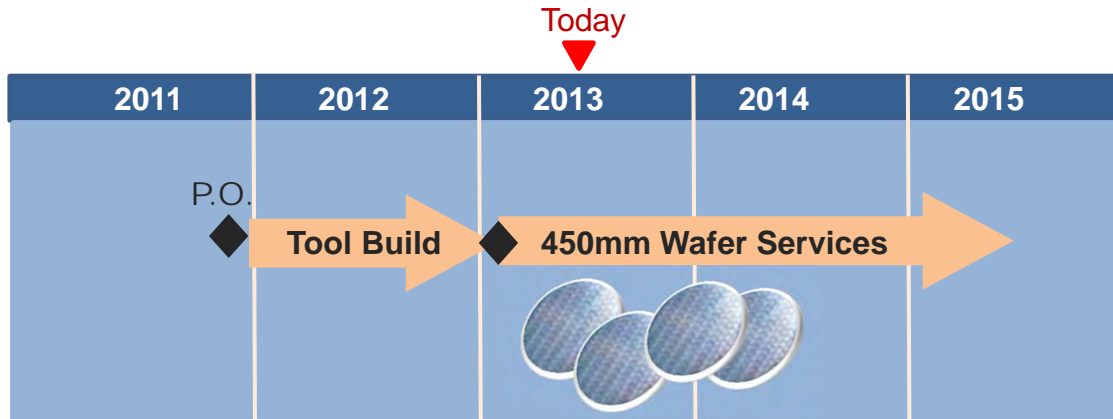
Imprio™ 450 Advanced Lithography



450mm Lithography Is Available Today

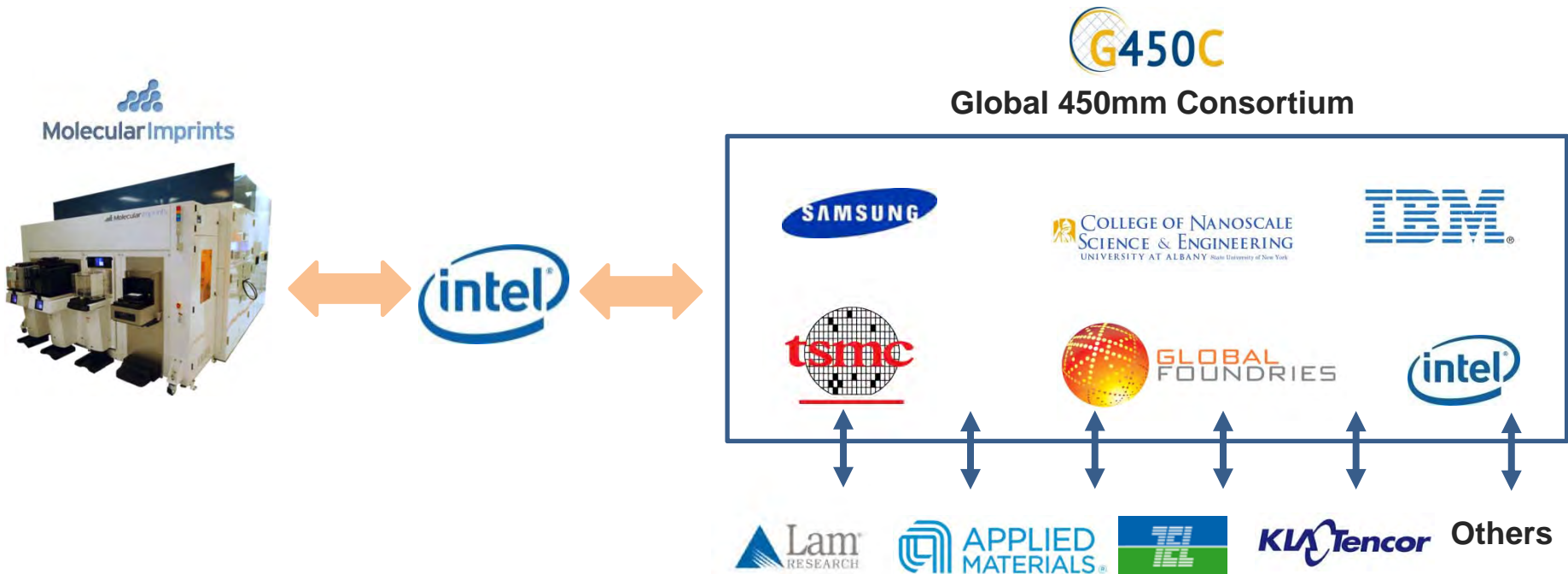
Molecular Imprints Awarded Contract from Leading IC Manufacturer to Provide Lithography Equipment and Wafer Patterning Services in Support of the Semiconductor Industry's 450mm Wafer Initiative

- ✓ ▶ PO Received Nov 2011
- ✓ ▶ Tool Accepted Dec 2012
- ✓ ▶ ***Wafer Services have begun Mar 2013***



450mm Lithography Wafer Services

Intel is managing all 450mm patterned wafer inquiries



MII is the Only Company Producing 450mm Patterned Wafers Today!

Jan 2013 – SEMI ISS at Half Moon Bay, CA



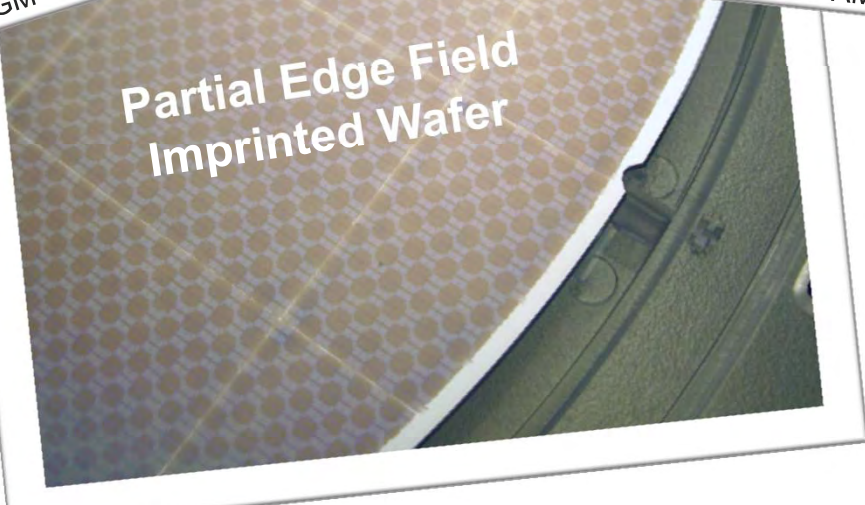
INTEL - Robert Bruck VP/IGM & Mario Abravanel 450 P

May 2013 – US Jobs & Opportunity Tour at Austin, Texas



President Obama and AMAT CEO Mike Splinter

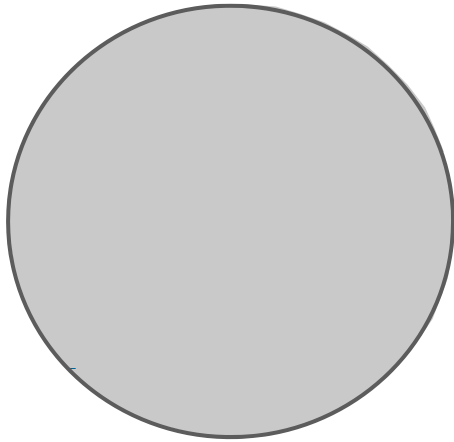
Partial Edge Field Imprinted Wafer



Wafer Scale Processes

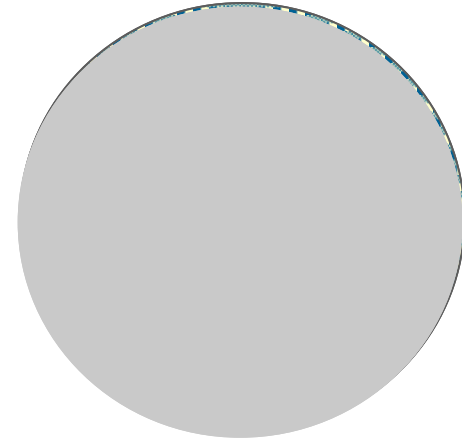
Realizing 450mm Wafer Cost Advantage

*“Litho cost has recently soared to ~50% of total wafer processing cost” **



Field-Scale Processing

- ▶ Optical Lithography*
- ▶ Nanoimprint Steppers
- ▶ Die-to-Die Inspection



Wafer-Scale Processing

- ▶ Etch
- ▶ Deposition
- ▶ CMP
- ▶ *Large Area Nanoimprint*

J-FIL for Backend Wafer Scale Processing

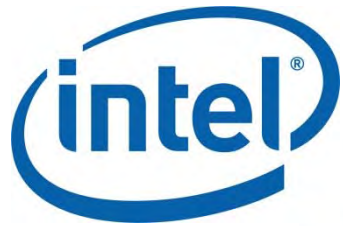
- ▶ J-FIL is already being scaled for Hard Disk Drive (HDD) and Flat Panel Display large area substrates
 - *Throughput 65mm HDD platters runs at 700 disks per hour with a CoO of less than 50 cents per disk!*
- ▶ 450mm Backend Patterning Could leverage the same CoO advantages
 - *Integrated resist jetting eliminates the need for track*
 - *Resist jetting has zero waste for significantly reduced consumable cost*
 - *Estimated 200+ WPH based on established models*

Molecular Imprints has some early customer pull for 450mm Wafer Scale Backend Lithography and is currently qualifying opportunity

Summary

- ▶ **Molecular Imprints systems continue to progress towards manufacturing ramp within the next 18 months**
 - *Defectivity, overlay, throughput performance within striking distance*
- ▶ **Industry infrastructure also preparing for 300mm ramp in 2014**
 - *Equipment partner's cluster module stepper in development*
 - *DNP's imprint mask capabilities achieving defectivity specs with impressive early 15nm 1X mask results*
- ▶ **Imprio 450 platform is ready today and under contract to provide patterning services to enable industry's 450mm timeline**
 - *Intel is managing wafer demand inquiries*

Acknowledgements



TOKYO ELECTRON

